Research on Safety Analysis and Response Methods of Autonomous Driving Technology Based on Artificial Intelligence

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***Abstract*—With the increasing attention paid to automated driving technology, the commercialization of automated driving has gradually become a reality, playing a vital role in transportation. However, the constant occurrence of autonomous vehicle accidents still makes the public doubt the possibility of large-scale commercial use of unmanned driving. How to improve safety and reliability is the core proposition of automated driving technology, Its research and development will seriously affect the commercialization of autonomous vehicle. This article focuses on the safety challenges that exist when key technologies of artificial intelligence are applied in the field of autonomous driving, analyzes the key factors that constrain the commercialization of autonomous driving, and proposes research ideas and suggestions to help the vigorous development of autonomous driving.**

Keywords—Automatic driving, artificial intelligence, safety analysis, response methods

I. INTRODUCTION

With the new revolution in artificial intelligence, reinforcement learning technology based on the Large Language Model (LLM) and the use of supervised learning and enhanced human feedback (RLHF) is a crucial part of achieving "intelligent and networked" automobiles. The implementation of autonomous driving technology needs to rely on the collaborative work of perceptual positioning systems, decision planning systems, and control execution systems. At the same time, the importance of data for autonomous driving is self-evident. Algorithms serve data, computational power serves algorithms, and data is the "source" of autonomous driving capabilities. The underlying layer of autonomous driving is a technology based on machine learning algorithms. Data is the foundation for algorithm modeling and software implementation. A large amount of data collection is a prerequisite for technology development. By introducing real person driving takeover data and continuously optimizing autonomous driving perception decision-making models, safety and reliability can be improved. In April 2022, five departments, including the Ministry of Industry and Information Technology, jointly issued the "Notice on the Trial Implementation of the Automobile Safety Sandbox Supervision System"[1], proposing new functions and new models to achieve autonomous driving at all levels. In August 2022, the Ministry of Science and Technology issued the "Notice on Supporting the Construction of New Generation Artificial Intelligence Application Scenarios"[2], which supports the construction of autonomous driving demonstration application scenarios. In November 2022, the Ministry of Industry and Information Technology and the Ministry of Public Security drafted the "Notice on Carrying out the Pilot Work of Access and Road Access for Intelligent Connected Vehicles (see draft)"[3], which stipulates that road access pilot work should be carried out for vehicles equipped with autonomous driving functions[4]. The above policies indicate that the autonomous driving track is becoming increasingly crowded, and more and more automobile enterprises are aware of the importance of autonomous driving. Therefore, building an autonomous driving safety system is an urgent issue to be solved, which can improve the level of standard application and support the safe and healthy development of the automobile industry.

In foreign countries, autonomous driving is becoming a key direction in the transformation of the automotive industry, and it has also been a focus of attention in the industry in recent years. In January 2020, the United States officially released a new version of the autonomous vehicle guidance document "Ensuring the U.S. Leadership in the Field of Autonomous Driving Technology: autonomous vehicle 4.0"[5], which established the guidelines for the development and integration of autonomous vehicle at the federal level. In August 2017, the UK Department of Transport and the National Infrastructure Protection Centre released the Key Principles for Network Security of Connected and Autonomous Vehicles[6]. In July 2017, France will automatically launch the "Artificial Intelligence Development Plan" and the "Action Plan for Promoting Growth and Enterprise Change"[7] to promote the development of autonomous driving technology. In September 2018, the Ministry of Land, Resources and Transport of Japan officially released the Safety Technical Guide for autonomous vehicle[8], which stipulates the safety conditions that must be met by L3 and L4 autonomous vehicle.

Domestic and foreign scholars have conducted in-depth research and mining in the field of autonomous driving, and formed rich scientific research results. Liu Xiuhong et al.[9] have found that autonomous driving is the highest level of vehicle safety technology, which can promote the organic combination of human, vehicle, and road traffic factors to ensure traffic safety; The method proposed by Liu Fawang et al.[10] provides a reference for comprehensive safety assessment of vehicles with autonomous driving functions

under specific design operating conditions. Tan Hong et al. [11] can assess the safety impact of different autonomous driving technologies in other countries through the developed framework and technical effectiveness; Kim Min Joong et al.[12] put forward an RSS model to ensure safety and reliability, which meets the minimum safety assurance standards for cars, to ensure the safety and reliability of autonomous vehicle. The above research mainly focuses on the importance of autonomous driving safety and safety assessment methods, and proposes some technical frameworks and models, but lacks safety analysis and corresponding countermeasures for autonomous driving technology.

This paper studies the breakthrough of artificial intelligence in automatic driving technology, analyzes the safety technical problems of auto drive system, explores how to rapidly promote the development and demonstration application of automatic driving technology, improve the safety and reliability of autonomous vehicle, and promote the high-quality development of the automobile industry.

II. Safety Challenges of Autonomous Driving Technology Based on Artificial Intelligence

With the rapid development of artificial intelligence, 5G, sensors and other related technologies, a good software and hardware foundation has been provided for the commercialization of autonomous vehicle. autonomous vehicle have become an inevitable trend in the automotive industry. Like traditional cars, the safety of cars is still the primary issue to be considered in the market-oriented application of autonomous vehicle, as shown in Figure 1. However, unlike traditional vehicles, the degree of electronic electrification of traditional vehicles is becoming higher and higher, and the hazards they face mainly come from the failure of electronic and electrical systems (ISO 26262 standard), and the vulnerability of vehicles to network interference and attack threats (ISO 21434 standard); At the same time, autonomous vehicle are also faced with the "black box" challenge of perception, decision-making and execution algorithms (ISO 21448 standard)[4], as well as the uncertainty of the performance of cognitive large model components based on supervised and unsupervised learning [13]. This paper analyzes and considers the current research situation of the deep integration of autonomous driving and artificial intelligence technology in China, as well as the safety risk issues caused thereby, providing valuable reference and reference for the research and development of autonomous driving technology.

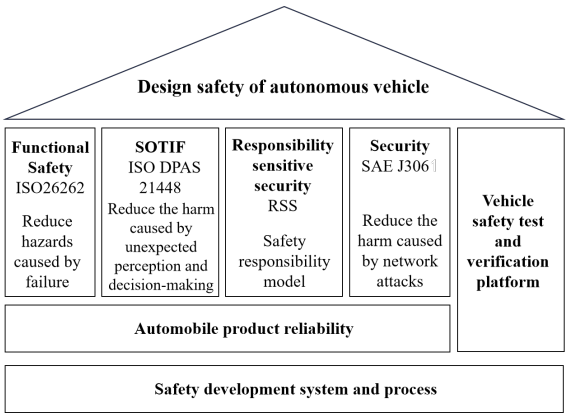

Figure 1. Framework of autonomous vehicle Safety Development Process

1) Auto drive system data security

Currently, China's intelligent connected vehicle industry is developing strongly, and national and local governments have successively introduced policies and regulations, promoting the development and commercialization of autonomous driving technology. However, as an important part of safety assurance, data is of self-evident importance to autonomous driving. Algorithms serve data, while computational power serves algorithms. Data is the "source" of autonomous driving capabilities.

Data is crucial to the construction and verification of automated driving artificial intelligence systems. It is the core of machine learning model learning process and the basis of algorithm modeling and software landing. A large number of data acquisition is the premise of automated driving technology development. "Data driven" is regarded as a basic idea to build autonomous vehicle. The key to data driven development is to build a data closed-loop system, including modules such as data acquisition, data annotation, data training, and data simulation, to jointly form a closed-loop system that is developed by data driven development and iterated functions, as shown in Figure 2. Autonomous vehicle are generally equipped with multiple sensors to collect millions of environment description data every second. These massive data sets provide basic support for complex and dynamic AI models. In order to prevent accidents in autonomous vehicles, it is crucial to systematically verify the security of these massive data sets to avoid network attacks such as virus attacks and escape attacks on vehicles.

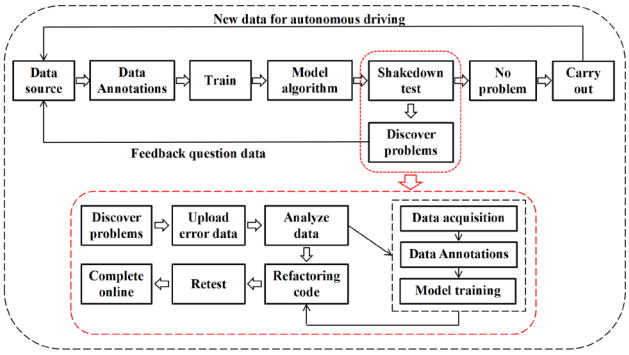

Figure 2. Data driven process framework of auto drive system

2) Algorithm safety of auto drive system model

With the development of key technologies for autonomous driving, players in the industry have become increasingly aware of the importance of model algorithms and computational power, which affect the safety of passengers and require real-time processing of massive amounts of data to make the most safe and reliable decisions. Automatic driving mainly includes three processes: perceptual positioning, decision planning, and control execution. As shown in Figure 3, first, point cloud data or image information is input into the perceptual positioning module using a model algorithm, then path planning is completed in the path planning module. Finally, control commands are executed in the behavior arbitration module, and then corresponding instructions are issued to the execution module. However, due to the uncertainty of the model algorithm itself, problems such as false detection, missed detection, and false detection often occur when facing

unknown objects or special poses and shapes. At the same time, when encountering key scenarios that have not been trained, incorrect predictions of the surrounding environment and incorrect decisions may occur. Therefore, how to solve the "black box" problem of the model algorithm of the auto drive system, continue learning and evolution, and make the "black box" gradually become "gray box", and then gradually become transparent, is another big problem that needs to be solved urgently.

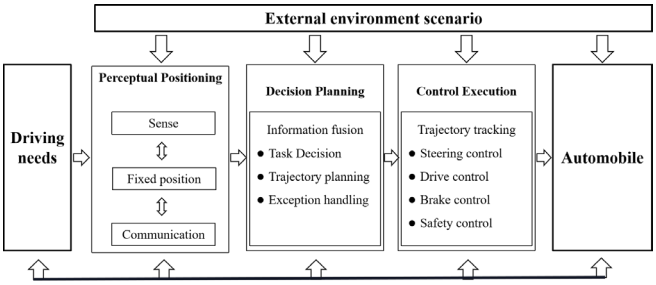

Figure 3. Automatic driving software and hardware coupling system

3) Automatic driving regulations and standards

In recent years, autonomous vehicle has gradually developed into a combination of automatic control, architecture, artificial intelligence, visual computing and many other technologies. It is the product of highly developed computer science, pattern recognition and intelligent control technologies. However, due to the acceleration of the development process of artificial intelligence technology and its particularity, the technology of autonomous vehicle has a high risk, such as the two consecutive Boeing 737Max aircraft crashes in 2018 and 2019[14], as well as the multiple fatal accidents of Tesla autopilot in the world, reflecting the urgent need to solve the safety problems of autopilot, However, the Road Traffic Safety Law (Revised Proposal) issued in March 2021 only introduces the auto drive system development unit as one of the responsible subjects, and does not define the "auto drive system development unit" and how to clarify the driving faults of drivers and auto drive system. The corresponding laws and regulations still need to be further improved, and safety standards and technical specifications need to be established.

III. Automatic Driving Technology Safety Response Method Based on Artificial Intelligence

In recent years, autonomous driving data closed-loop has gradually become a hot topic in the automotive industry, and many autonomous driving companies are trying to create their own data closed-loop systems. However, the data related to automatic driving is not only huge, but also diverse, including vehicle data, location data, environment awareness data, application data, personal data, etc. How to build a data closed-loop system is an urgent problem to be solved for improving the ability of the auto drive system. In an autonomous driving scenario, data is collected by a test vehicle, labeled, and then trained with the new data for a neural network model. Finally, it is deployed to the vehicle end through OTA. A complete data closed-loop usually includes data collection, data reflow, data processing, data annotation, model training, test validation, and other links. As shown in Figure 4, new data sources are constantly triggered and transmitted back, forming a data-driven iterative development cycle. Therefore, the establishment of a unified data closed-loop system can not only improve the efficiency of data collection, improve the generalization ability of models and the iteration of driving algorithms, thus improving the function and performance of automotive products, and enabling the auto drive system to have the ability of continuous evolution.

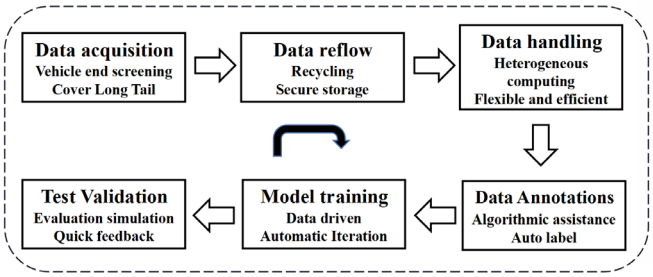

Figure 4. Auto drive system data closed-loop flow chart

In response to the most difficult long tail problem of autonomous driving, most autonomous driving enterprises adopt the solution of big data+AI training to cover all possible driving scenarios by collecting larger scale driving data and testing longer driving distances, making cars increasingly "smart" under the supervision of safety officers. However, various new road conditions and new traffic emergencies can occur at any time. People are constantly solving new problems, approaching perfection, but they will never be completely perfect. By using the implementation idea of ChatGPT for reference and adopting the human feedback reinforcement learning (RLHF) technology[15], all scenarios are considered as unknown scenarios without distinction at the initial stage, and a large amount of data is input into the algorithm. Through self-learning and improvement, the AI model tests the coping ability and autonomous improvement ability of the technology in more driving scenarios, and continuously collects test data to meet the requirements of safe and reliable autonomous driving, as shown in Figure 5. Therefore, generative AI trains, tests, and verifies the safety and accuracy of model algorithms through real-world data, providing high-quality synthetic data for autonomous driving model training, solving autonomous driving data and testing challenges, and accelerating the commercialization of autonomous driving.

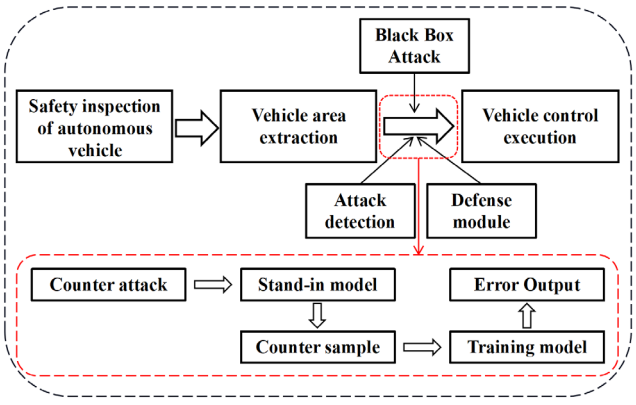

Figure 5. Auto drive system continuous learning training model process

The rapid development of autonomous driving technology has brought new topics, and also posed a new test for the development of autonomous driving in China. In the past year, the national and local governments have successively introduced relevant laws and regulations,

making phased progress, providing strong support for the demonstration application of autonomous vehicle. However, despite the continuous acceleration of the construction of relevant demonstration application areas, people have seriously questioned the issue of liability determination for autonomous driving accidents. So far, there is no clear specification for liability determination for autonomous driving accidents at both the local and national levels, which not only brings uncertainty to the development of autonomous driving, but also adds confusion to demonstration applications. Intelligent Internet connectivity demonstration zones in multiple regions of China are in the ascendant period of rapid development, and the legislative conditions are basically mature. The government departments have issued corresponding laws and regulations to regulate their driving and responsibility distribution, accelerate the implementation of relevant standards and technical specifications, and gradually upgrade them from one point to another. They can start at the local level and then to the national level, forming a legal system with Chinese characteristics, Jointly march towards the "intellectual high point" of autonomous driving in China.

IV. Conclusion and Outlook

With the breakthroughs of artificial intelligence in deep learning, computer vision, and large model algorithms, it has laid the foundation for the development of autonomous driving and rapidly promoted its progress. The core competitiveness of autonomous driving lies in its software and soft hard coupling capabilities, which solve the security challenges of data and algorithms. It continuously iterates new algorithms on a stable and unchanging dataset to improve model performance and efficiency, and is more conducive to achieving fast iteration of driving models, creating differentiated functional experiences and product services. By analyzing the safety problems of autonomous vehicle using artificial intelligence technology, this paper explores how to establish a safe and reliable technology system for automated driving, accelerate the commercialization of automated driving technology, and puts forward some suggestions: 1) build a closed-loop system for automated driving data, so that data can flow efficiently within the system; 2) Using big data+feedback reinforcement learning technology to enable big models to self-learning and improve; 3) Improve relevant laws and regulations, accelerate the implementation of standards and technical specifications.

Acknowledgements

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